SELENIUM AND TELLURIUM

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Selenium and tellurium, rare elements widely distributed within the Earth's crust, do not occur in concentrations high enough to justify mining solely for their content. They are recovered as byproducts, mostly from the anode slimes associated with electrolytic refining of copper. Electrolytic refining utilizes a sulfate-based electrolyte for its role in absorbing copper ions on the cathode. This type of electrolyte does not dissolve precious and base metals, allowing them to accumulate along with refractory components at the bottom of the electrolytic cell. The amount of such metals as bismuth, gold, selenium, silver, and tellurium recovered is dependent on their initial content in the anode material and, therefore, on the ores from which the copper concentrate originated.

Slimes resulting from primary copper metal refining can have average selenium concentrations of 10% and in a few cases as high as 40%. Tellurium concentrations are generally lower, 5% being the maximum (Weerts, 2002).

Domestic production of primary selenium decreased in 2003. Selenium and tellurium can be recovered economically from industrial scrap and chemical process residues. Manufacturers recycle obsolete and damaged photoreceptor drums from copy machines, and these drums are shipped to refineries for recovery of selenium and tellurium metal. About 15% of refined selenium production comes from these secondary sources (Selenium-Tellurium Development Association, 2002c§[1]).

Selenium, a nonmetal, is chemically similar to sulfur but with some metallic properties. It is used as a photoreceptor in copiers in the form of arsenic triselenide; in pigments as cadmium sulfoselenide; as a decolorizing agent in the glass industry; and in the metallurgical industry to improve the properties of copper, lead, and steel with which it is alloyed.

The major use of tellurium is as an alloying additive in copper, iron, and steel to improve machining characteristics. It is also used as a catalyst in the chemical industry and in electronic applications, such as photoreceptors and thermoelectric and photovoltaic devices. The electronic applications of tellurium were a growing end use in 2003.

Domestic Data Coverage

Domestic data are collected through a voluntary survey of U.S. selenium and tellurium producers. The production survey was sent to the two known domestic producers of selenium and the sole domestic producer of tellurium. All companies responded to the survey. Survey data were withheld from publication to avoid disclosing company proprietary data.

Legislation and Government Programs

On July 21, 2003, the Manganese Metal Control Act of 2003 was introduced. It authorized the U.S. Environmental Protection Agency to study the potential injurious effects of imported electrolytic manganese that contains selenium to the environment and human health (U.S. House of Representatives, 2003§). The major producing countries of manganese metal are China and South Africa. There are two ways of producing electrolytic manganese. In South Africa, the method uses sulfur dioxide (SO_2), while China's method uses selenium dioxide (SeO_2). The latter method, while increasing energy efficiency, causes elevated levels of selenium in emissions, manganese metal, and waste, which can be detrimental to the environment. The United States, on average, imports approximately 63% of its manganese metal from South Africa and 22% from China (Corathers, 2004§).

Production

About 250 metric tons per year (t/yr) of secondary selenium is produced worldwide. World refinery production of primary selenium (excluding U.S. production) decreased by about 2% to 1,430 metric tons (t) (table 5). Japanese output, which accounted for approximately 50% of the world total, was reported to have decreased by 5% to 715 t. Belgium, Canada, Japan, and the United States represented more than 80% of the total world refinery production of selenium and tellurium. Most of the selenium and tellurium mined in the United States was from Arizona, New Mexico, and Utah.

The major world producers of refined tellurium were Canada, Japan, Peru, and the United States (table 6). In the United States, one firm recovered tellurium from anode slimes produced in copper refining and from soda slag skimmings generated in lead refining. Secondary tellurium was not produced domestically, but some scrap was exported for recycling. Production data reported to the U.S. Geological Survey (USGS) are treated as company proprietary information.

Selenium.—Global selenium output cannot be easily determined because not all companies report production and because of the trade in semirefined production. Only about 20 of the approximately 80 copper refineries in operation around the world reported

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[1]References that include a section mark (§) are found in the Internet References Cited section.

recovery of selenium, and less than one-half of that number reported tellurium refining (Selenium-Tellurium Development Association, Inc., 2002). Domestic production of selenium was lower in 2003 than in 2002. In the United States, only one domestic copper refinery recovered refined selenium—ASARCO Incorporated, Amarillo, TX. One domestic producer exported semirefined selenium (90% selenium content) for toll-refining in Asia. Three other companies generated selenium-containing slimes but did not produce selenium. Selenium-containing slimes from these refineries were exported for processing. It is estimated that, with the higher prices, domestic producers reduced their inventories of selenium material.

Most domestic selenium is produced as commercial-grade metal, averaging a minimum of 99.5% selenium and is available in various forms. This commercial-grade selenium is also further refined to make minimum-99.999% selenium for use in thermoelectric applications.

Tellurium.—Data on the production of tellurium were not readily available. The world's leading producers, Asarco in the United States and n.v. Umicore s.a. in Belgium, do not publish production figures. Asarco produced commercial-grade tellurium at its refinery complex in Amarillo mainly from copper anode slimes but also from lead refinery skimmings. Asarco also produced tellurium, selenium, and compounds of these metals in high-purity form for specialty applications at its Globe plant in Denver, CO. Domestic tellurium production was estimated to have decreased in 2003 compared with that of 2002.

Consumption

The average global consumption of selenium during the past 4 years is estimated to have been about 2,000 t/yr. The USGS estimated that the global end-use demand in 2003 was as follows: glass, 35%; chemicals and pigments, 20%; electronics, 12%; metallurgy, 24% and other uses, 9%. Domestic consumption is thought to have decreased in 2002.

Metallurgical uses dominate tellurium demand, estimated to be about 220 t/yr. In 2003, about 45% of the tellurium was used as an alloying element to improve the properties of iron and steel, and 10% was used as an additive to nonferrous metals. Other domestic uses included catalysts and chemicals, 25%; photoreceptors and thermoelectric devices, 13%; and digital video discs (DVDs) and other minor uses, 7%.

Selenium.—In glass manufacturing, selenium is used to decolorize the green tint caused by iron impurities in glass containers and other soda-lime silica glass. It is also used in art and other glass, such as that used in traffic lights, to produce a ruby red color and in architectural plate glass to reduce solar heat transmission through the glass.

More than one-half of the metallurgical selenium is used as an additive to cast iron, copper, lead, and steel alloys. In these applications, it improves machinability and casting and forming properties.

The use of selenium as an alloy with bismuth to substitute for lead in plumbing continued to increase during 2003 in response to requirements of the Safe Drinking Water Act Amendments of 1996 (Public Law 104-182). The Act requires that no lead be contained in any fixtures, fluxes, pipes, and solders used for the installation or repair of facilities that provide water for human consumption after August 1998.

The addition of a small amount, about 0.02% by weight, of selenium to low-antimony lead alloys used to support the grid of lead-acid batteries improves the casting and mechanical properties of the alloy. Other uses, mainly agricultural, compose about 9% of the selenium market.

Although it is a diminishing end-use market, electronics accounted for 12% of selenium use. Photoreceptors on the drums of plain-paper copiers had been the largest single application for selenium during the 1970s and 1980s. Organic photoreceptor compounds (OPCs) have replaced these high-purity selenium compounds. OPCs are free of the environmental concerns involved with the disposal of selenium compounds and reportedly offer better performance and cost at lower printing speeds. In 2003, selenium was used to make replacement parts for older copiers. While use in photoreceptors has been declining, other electronic uses for selenium, including rectifier and photoelectric applications, have been growing.

Chemical uses of selenium, which account for approximately 20% of use, include industrial and pharmaceutical applications. Dietary supplements for livestock and humans are a small portion of this category. Selenium added to fertilizer is the larger portion of this category, where it is used in growing animal feed. This practice is more common outside the United States, especially in countries with selenium-poor soils. Selenium's principal pharmaceutical use is in shampoo to control dermatitis and dandruff.

Cadmium sulfoselenide compounds are used as pigments in ceramics, glazes, paints, and plastics. Selenium in pigments has good heat stability, reacts well to moisture, and is resistant to ultraviolet or chemical exposure. It can be used to produce a wide range of red, orange, and maroon colors, but because of the relatively high cost and the toxicity of cadmium-based pigments, their use is generally restricted.

Additionally, selenium is used in catalysts to enhance selective oxidation; in plating solutions, where it improves appearance and durability; in blasting caps and gun bluing; in coating digital x-ray detectors; and in zinc selenide for infrared windows in carbon dioxide lasers (Amalgamet Canada, 2003§). In addition, China used SeO_2 to increase yields in the electrolytic production of manganese (Selenium-Tellurium Development Association, 2002a§).

Tellurium.—World demand for tellurium is believed to have decreased in 2003. The largest use for tellurium was as a metallurgical alloying element. Approximately 55% of the market demand for tellurium was as an alloy in steel as a free-machining additive, in copper to improve machinability while not reducing conductivity, in lead to improve resistance to vibration and fatigue, in cast iron to help control the depth of chill, and in malleable iron as a carbide stabilizer.

Chemical and catalyst usage made up about 25% of the world market, with tellurium being used as a vulcanizing agent and accelerator in the processing of rubber and as a component of catalysts for synthetic fiber production. Electrical uses, such as photoreceptor and thermoelectric applications, accounted for about 13% of tellurium demand. Other uses, as an ingredient in blasting caps and as a pigment to produce blue and brown colors in glass and ceramics, were about 7% of consumption (Selenium-Tellurium Development Association, 2002b§).

Tellurium catalysts are used chiefly for the oxidation of organic compounds but are also used in chlorination, halogenation, and hydrogenation reactions. Tellurium dioxide is used as a curing and accelerating agent in rubber compounds.

High-purity tellurium is used in electronics applications, such as thermoelectric and photoelectric devices. Thermal imaging devices use mercury-cadmium telluride. This material assists in converting a raw image into a crisp picture on the screen. Semiconducting materials that use bismuth telluride are being employed in electronics and consumer products as thermoelectric cooling devices. These devices consist of a series of couples of semiconducting materials which, when connected to a direct current, cause one side of the thermoelement to cool while the other side generates heat.

These thermoelectric coolers are most commonly used in military and electronics applications, such as the cooling of infrared detectors, integrated circuits, laser diodes, and medical instrumentation. Their application in consumer products, such as portable food-and-beverage coolers, continues to increase. Although electronics applications consumed lesser quantity as compared with other end uses, the value of their consumption exceeded that of the rest of the end uses.

Prices

Platts Metals Week's average New York dealer price for selenium was $5.68 per pound in 2003. From the beginning of the year up until mid-June, the price was stable at $3.80 to $4.30 per pound. In late June, Chinese consumers placed a large number of bids for selenium. Since the supply of and demand for selenium were almost equal, this large increase in demand for selenium pushed the price into a steady upward trend for the rest of the year. At the end of the year, the price was $8.75 to $10.50 per pound.

In the United States, the price of specialty products of tellurium produced by the sole producer climbed by $1 per pound for the third consecutive year to $17.00 per pound. The United Kingdom price for lump and powder 99.95% tellurium, as published in Mining Journal, started the year at an average of $8.00 per pound. In late May, the price increased to $9.00 per pound. In early August and again in late August, the price increased by $0.50 increments, ending the year at $10.00 per pound.

Trade

International trade is important to U.S. selenium and tellurium markets. In 2003, exports of selenium metal and waste and scrap increased by 181% compared with those of 2002, on a weight basis. The Philippines was by far the largest market for selenium metal, scrap, and waste from the United States, accounting for almost 73% of these exports (table 2). Since the price was high, any inventories held by producers and consumers were exported to the Philippines, where they were then processed and exported to China (Mining Journal, 2004).

In 2003, imports of SeO_2 unwrought waste and scrap decreased by 13% to 367 t, compared with revised 2002 imports (table 3). The United States was a net importer of selenium in 2003 by 124 t (including the selenium content of SeO_2) compared with 336 t in 2002. Canada, the Philippines, Belgium, and Germany, in order of decreasing quantity, were the leading foreign suppliers to U.S. selenium markets. They accounted for 88% of the imports of selenium metal and SeO_2 into the United States in 2003.

Imports of unwrought tellurium and tellurium waste and scrap, on a gross weight basis, increased by almost 74% during the year (table 4). The leading suppliers were Belgium, Germany, Canada, and the Philippines, in order of decreasing quantity, accounting for 93% of the total imports of tellurium metal into the United States. Data for tellurium exports were not available.

World Review

The Selenium-Tellurium Development Association (STDA) ceased operating in early 2003 after serving the industry for more than a decade.

World production and consumption data for selenium and tellurium are limited. World refinery production of selenium was estimated to have remained stable in 2003 (table 5). A slight decrease was seen in Japanese production of selenium and tellurium. In spite of various closures, cutbacks, and interruptions in the copper industry, world production of both byproducts has been fairly steady during the past few years.

The driving force behind the worldwide demand increases for selenium was the growing economy of China. Currently there is little to no selenium being sold because there is no supply. Long term contracts and China's recent purchases have exhausted the production and inventories of the world.

China.—Jinchuan Group, China's largest nickel and cobalt producer, reported that it produced 11 t of selenium. This was 122% of what it expected to produce (Metals-Pages, 2003b§).

China consumed much of the world's production of selenium. In mid-2003, China started importing large quantities of selenium, which caused the price to soar. The reason behind the significant increase in consumption has been linked to the increased production of manganese needed by the Chinese steel industry in one of the world's fastest growing economies (Metal-Pages, 2003d§). Also Chinese builders favor the use of 1-inch-square mosaic tiles, which are placed on most buildings; selenium is used to make all the shades of red used in these tiles, and there has been a strong increase in demand for these tiles (Roskill's Letters from Japan, 2003). In China, red is a very popular color (Metal-Pages, 2003c§). Also, China's soil is very poor in selenium content. To correct this, Chinese fertilizers and animal feed use selenium additives to ensure adequate selenium intake in the diet of Chinese people (Metal-Pages, 2003a§).

Japan.—Four of the major producers of selenium in Japan are Mitsubishi Materials Corporation; Nippon Mining & Metals Co., Ltd.; Shinko Kagaku Kogyo Co., Ltd.; and Sumitomo Metal Mining Co., Ltd. Selenium production decreased by 7% in 2003 compared with that of 2002 (Roskill's Letter from Japan, 2004a). Approximately 50% of Japanese production of selenium was exported directly to China in 2003. Most of the 236 t of selenium exported to China was used in ceramic tiles. Other destinations of Japanese selenium were Hong Kong, India, and the United Kingdom, in descending order of quantity. The domestic demand for selenium was in glass production (Roskill's Letter from Japan, 2004b).

Tellurium output was reduced by 48% in 2003 compared with that of 2002. Producers and consumers increased their inventories to 26.7 t in 2003 from 21 t in 2002, representing a 27% increase (Roskill's Letter from Japan, 2004a).

Russia.—The Russian copper refiner Uralelektromed JSC increased production of selenium by almost 54% and tellurium by 19% in 2003. Much of the increased selenium production is related to new technology that makes the processing of selenium more completely enclosed and enables the direct recovery of selenium from dust by adding new gas cleaning systems (Metal-Pages, 2003f§).

Current Research and Technology

Selenium's antioxidant and curative properties have been demonstrated through research to assist with a number of human health problems. The use of selenium as a dietary supplement has been shown to have a positive effect on the following health problems: acquired immune deficiency syndrome (AIDS), Alzheimer's disease, arthritis, asthma, cancer, cardiovascular diseases, pancreatitis, reproduction, thyroid function, and viral infections (Oldfield, 2003). Research is ongoing into the role of selenium in reducing the risk of skin cancer from exposures to ultraviolet radiation. Also, there have been many new promising medical studies on the possibility of selenium reducing the risk of prostate cancer (Metal-Pages, 2003e§). The amount of selenium for individual doses is relatively small. However, some countries, including Finland and New Zealand, have added selenium to fertilizers to increase the low selenium content of soils. This use requires much larger amounts of selenium than using selenium as a dietary supplement (Oldfield, 2003).

DayStar Technologies has developed a thin-film solar cell called the CIGS solar cell, which is made up of copper, gallium, indium, and selenium. The CIGS solar cell converts sunlight directly into energy. Currently, DayStar is developing a high-volume manufacturing process and predicts that solar electricity power production will become commercial in the near future (DayStar Technologies, 2004§). In other solar cell news, researchers in Berkeley, CA, are working on new solar cells that use magnesium, tellurium, and zinc to produce the optimal solar cell (SolarAccess, 2004§).

Japan's Tosoh Corporation has developed a new catalyst by using palladium and tellurium. The catalyst can be used to synthesize phenol from benzene with significant environmental advantages. Tosoh hopes to increase the benzene conversion ratio, which would make the catalyst more economical than current catalysts (Metal-Pages, 2003h§).

Outlook

The supply of selenium is directly affected by the supply of the main product from which it is derived, copper, and also, to a lesser extent, by the supply of nickel where the nickel production is from a sulfide ore. The selenium price is often inversely related to the supply of copper. For example, as a byproduct of copper refining, selenium prices typically fall during periods of high copper production. However, in 2003, the driving force behind the increased price was short supply and large demand. Since selenium price has no influence on copper producers, a jump in price will not cause a jump in the production of copper and its byproducts.

Copper mine and refinery production in the United States and in the world are expected to increase during 2004 (Edelstein, 2004§). This in turn is expected to cause a minor increase in the production of selenium and tellurium. Many of the newer copper mines have a lower selenium and tellurium content than the older mines (Ryan's Notes, 2003). Also, as more copper refiners switch from electrolytic to electrowinning processing, the supply of selenium will drop. The electrowinning processing does not have the capability of capturing the byproducts, but the electrolytic process can recover byproducts. Not all copper ores can be processed by electrowinning, but many refiners in the United States have switched to this process. Even with the lower selenium and tellurium content of ore and electrowinning causing decreases in the supply of selenium and tellurium, the production for 2004 will probably increase slightly. China will continue to use much of the world's supply in the short term.

With the high price of selenium, there is a large risk of substitution, especially in the glass industry, which is the largest consumer of selenium (Mining Journal, 2003). If the price continues to increase and if high selenium-content manganese is outlawed in the United States, the Chinese manganese producers will investigate using SO_2 instead of SeO_2.

Demand for selenium in photoreceptors is likely to continue to decline as the cost of substituting organic compounds decreases. Promising prostate cancer research and other health benefits may eventually lead to increased consumption of the metal. Dosages taken directly for human consumption will not induce large increases in demand for the metal because only minute quantities are necessary for effective therapy. Nevertheless, there could be a relatively large consumption increase if selenium is applied directly to the soil for crops to be consumed by humans or livestock.

Tellurium supply and demand has remained in fairly close balance for a decade. With the expected increases in copper production, an increase in production, although minor, of tellurium is expected. An increase in demand for high-purity tellurium for cadmium-telluride solar cells and for bismuth-telluride thermoelectric devices might have a major impact on tellurium consumption. Tellurium alloys used in DVDs consume only small amounts of tellurium and will, therefore, have minimal impact on tellurium demand (Metal-Pages, 2003g§).

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TABLE 1
SALIENT SELENIUM AND TELLURIUM STATISTICS[1]

(Kilograms, contained metal, and dollaras per pound)

	1999	2000	2001	2002	2003
Selenium:					
United States:					
Production, primary refined	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Exports, metal and waste and scrap	233,000	82,100	41,200	86,700 r	243,000
Imports for consumption[2]	326,000	476,000	483,000	422,000 r	367,000
Apparent consumption, metal	W	W	W	W	W
Dealers' price, average, commercial grade[3]	$2.50	$3.84	$3.80	$4.27	$5.68
World, refinery production	1,410,000	1,460,000	1,460,000 r	1,460,000 r	1,430,000 e
Tellurium, United States:					
Imports for consumption[4]	38,000	52,300	28,000	28,100 r	48,900
Producer price quote, yearend, commercial grade[5]	$15.00	$14.00	$15.00 r	$16.00 r	$17.00

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits, except prices.
[2]Includes unwrought waste and scrap and selenium dioxide.
[3]Source: Platts Metals Week. Calculated from published price ranges.
[4]Includes only wrought and waste and scrap.
[5]Yearend prices quoted by sole producer for specialty product.

TABLE 2

U.S. EXPORTS OF SELENIUM METAL AND WASTE AND SCRAP[1]

Country	2002 Quantity (kilograms, contained Se)	2002 Value	2003 Quantity (kilograms, contained Se)	2003 Value
Australia	2,450 r	$37,900 r	13,800	$207,000
Aruba	--	--	210	3,240
Belgium	1,370	21,200	18,700	290,000
Brazil	734 r	11,400 r	--	--
Canada	2,380 r	66,200 r	969	27,800
China	339	5,840	4,900	50,900
Colombia	--	--	100	8,330
Costa Rica	541	5,100	1,750	26,100
El Salvador	1,500 r	16,200 r	--	--
France	578	8,950	619	9,580
Germany	--	--	302	4,680
Hong Kong	--	--	2,290	21,000
Israel	178	2,760	--	--
Japan	1,070	16,600	978	20,800
Korea, Republic of	--	--	2,030	23,900
Mexico	646 r	10,000 r	9,030	97,700
Netherlands	379	5,860	--	--
Philippines	72,700	510,000	177,000	1,400,000
Singapore	1,130	18,300	5,230	58,600
South Africa	163	3,920	--	--
Venzuela	--	--	5,550	51,000
United Kingdom	500	3,500	--	--
Total	86,700 r	744,000 r	243,000	2,090,000

r Revised. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF SELENIUM[1]

Class and country	2002 Quantity (kilograms, contained Se)	2002 Value	2003 Quantity (kilograms, contained Se)	2003 Value
Unwrought waste and scrap:				
Belgium	62,900 r	$767,000 r	69,600	$837,000
Canada	249,000 r	1,410,000 r	119,000	1,700,000
China	34	9,320	--	--
France	750 r	7,230 r	--	--
Germany	10,100 r	124,000 r	23,100	317,000
Hong Kong	6,000	46,500	--	--
India	1,410	42,300	11,200	335,000
Japan	3,510 r	99,000 r	4,610	139,000
Korea, Republic of	13,000	88,800	20,500	196,000
Peru	--	--	907	6,000
Philippines	47,300 r	581,000 r	102,000	856,000
Russia	8,060	71,400	--	--
Switzerland	10	2,400	--	--
United Kingdom	8,480 r	60,600 r	2,230	24,800
Total	410,000 r	3,310,000 r	353,000	4,410,000
Selenium dioxide:[2]				
Germany	11,400 r	120,000 r	11,100	131,000
India	--	--	2,840	31,400
Japan	354	1,960	354	2,820
Philippines	354	4,150	--	--
Spain	142	2,220	213	3,760
Total	12,200 r	129,000 r	14,500	169,000
Grand total	422,000 r	3,440,000 r	367,000	4,580,000

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Totals revised to 71% of original quantities and values.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM[1]

	2002		2003	
Class and country	Quantity (kilograms, gross weight)	Value	Quantity (kilograms, gross weight)	Value
Unwrought waste and scrap:				
Belgium	5,470 r	$188,000 r	17,500	$305,000
Canada	2,690 r	670,000 r	8,170	650,000
China	118 r	45,300 r	190	64,800
Germany	9,700 r	242,000 r	15,700	297,000
Japan	14	23,100	12	22,600
Kazakhstan	1,980	30,400	--	--
Philippines	6,580 r	430,000 r	4,230	137,000
Ukraine	1,210 r	121,000 r	11	43,700
United Kingdom	337	15,500	3,050	88,600
Total	28,100 r	1,770,000 r	48,900	1,610,000

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

SELENIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained selenium)

Country[3]	1999	2000	2001	2002	2003[e]
Belgium[e]	200,000	200,000	200,000	200,000	200,000
Canada[4]	359,000	350,000	238,000	226,000	230,000
Chile[e]	49,000	40,000	40,000	40,000	40,000
Finland	26,000 e	36,293	38,913	39,000	39,500
Germany[e]	100,000	100,000	100,000	100,000	100,000
India[e, 5]	11,500	11,500	11,500	11,500	12,000
Japan	546,292	612,316	735,089	752,099 r	715,000
Peru	23,008	21,000	16,000	16,000	16,000
Philippines[e]	40,000	40,000	40,000	40,000	40,000
Serbia and Montenegro	20,080	20,000 e	20,000 e	15,000 r	15,000
Sweden[e]	20,000	20,000	20,000	20,000	20,000
United States	W	W	W	W	W
Zambia[6]	11,620	9,820 e	-- r	-- r	--
Total[7]	1,410,000	1,460,000	1,460,000 r	1,460,000 r	1,430,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1]World totals and estimated data have been rounded to three significant digits; may not add to totals shown.

[2]Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and/or refinery residues but did not recover refined selenium from these materials indigenously were excluded to avoid double counting. Table includes data available through May 27, 2004.

[3]In addition to the countries listed, Australia and some countries of the Commonwealth of Independent States, including Kazakhstan, Russia, and Uzbekistan, produced refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United Kingdom has facilities for processing selenium scrap.

[4]Excludes selenium intermediates exported for refining.

[5]Data are for fiscal year beginning April 1 of year stated.

[6]Reporteted figure.

[7]Does not include U.S. data, which are withheld to avoid disclosing company proprietary data.

TABLE 6

TELLURIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1]

(Kilograms, contained tellurium)

Country[2]	1999	2000	2001	2002	2003[e]
Canada[3]	64,000	53,000	51,000	45,000	45,000
Japan	35,272	35,687	39,008	28,656 [r]	28,000
Peru	17,110	22,000	19,000	20,000	20,000
United States	W	W	W	W	W

[e]Estimated data are rounded to no more than three significant digits. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and/or refinery residues but did not recover refined tellurium are excluded to avoid double counting. Table is not totaled because of exclusion of data from major world producers, notably the Commonwealth of Independent States and the United States. Table includes data available through May 27, 2004.

[2]In addition to the countries listed, Australia, Belgium, Chile, Germany, the Philippines, and some countries of the Commonwealth of Independent States, including Kazakhstan and Russia, are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels.

[3]Excludes tellurium intermediates exported for refining.